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MODELING OF AN OPTICAL NEURON

Abstract:. Recently, the landscape of commercially made photon chips is changing rapidly, and now it promises to achieve economies of scale, which was previously used exclusively by microelectronics. This article discusses the classification of neuron modeling, and hardware implementations based on optoelectronic elements

Keywords: neuromorphic calculations, neural networks, neural modeling, optical neuron

There are already several classifications for modeling a neuron. Namely, classified by successor features [1]:

- By form of information presentation (digital or analog);
- Type of element base (electronic, hybrid and opto-electron);
- - the nature of the setting of synapses (constant or variable);
- Signal transmission time (synchronous or asynchronous);
- By the nature of the setting of synapses (fixed or infused weights);

Among the optoelectronic element base can be divided into the following groups:

- Based on photodiodes and operational amplifiers;
- Based on managed banners;
- Based on optical bistable SEED devices;
- Based on space-time modulators;

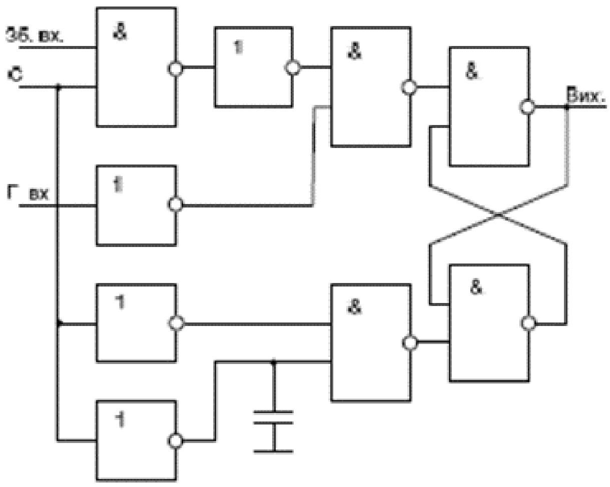

Fig.1 Model of a formal neuron

An example of a digital one-bit model is the model of a formal neuron (Fig. 1) [2]. The model is based on the usual R-S trigger. I-No logic elements, transistors, and sometimes an ionotron transistor are also used. This model is very simplified because the input and output signals are binary.

A more generalized classification of INS divides them into two classes (Fig. 2) depending on the availability of feedback. In the absence of feedback is called static, and in its presence - dynamic (recurrent).

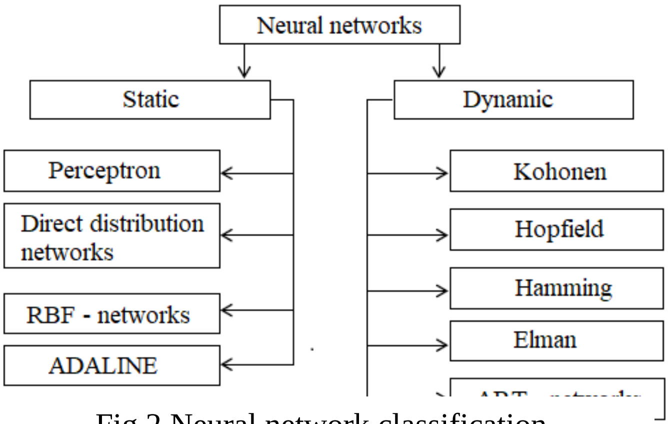

Fig.2 Neural network classification

Developed digital signal processor EnLight256 [3]. This device consists of an optical vector-matrix multiplier, a vector digital processing module and a standard scalar DSP. This construction allows you to calculate 8-ter multiplication and accumulation operations per second. For the clock period, it multiplies the 256-byte vector by the 256-byte matrix. It uses lasers, detectors, lenses and optical modulators included in the optical core.

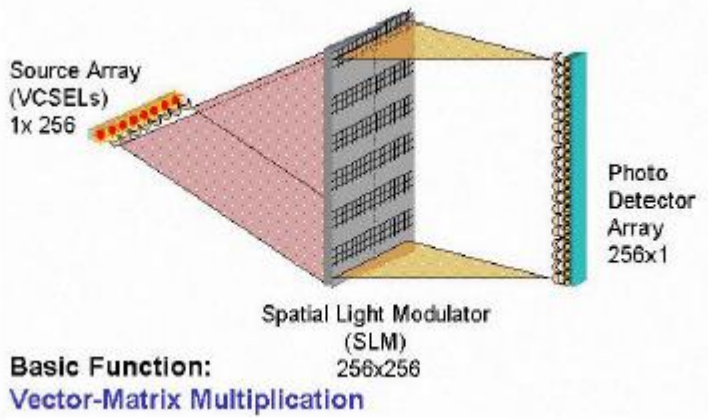

Fig.3 Basic design of the optical

The figure shows the basic design of the optical core. The input vector consists of 256 incoherent lasers. The spatial light modulator can implement 64k simultaneous multiplications on a single chip. The output signal is generated by detectors that are formed into a column of 256 world detectors integrated with an analog-to-digital converter.

Each element of the input vector is projected into the column of the spatial modulator. Each line from the spatial modulator is projected onto the detector vector. As a result, the energy in the detector can be calculated by the formula:

$$Y_i = \sum_{j=0}^{255} X_j \cdot a_y$$

where Y_i – output signal from the detector column

X_j – input signal from the laser vector a_y – element of the spatial modulator matrix.

As a result of operation of an optical kernel we receive multiplication of a vector matrix for one measure.

The Massachusetts Institute of Technology is also developing a coherent optical neural network scheme [4]. Namely, a model of a neuron from a laser with radiation of vertical cavities. The neural network consists of an optical interference block and an optical unit of nonlinearity.

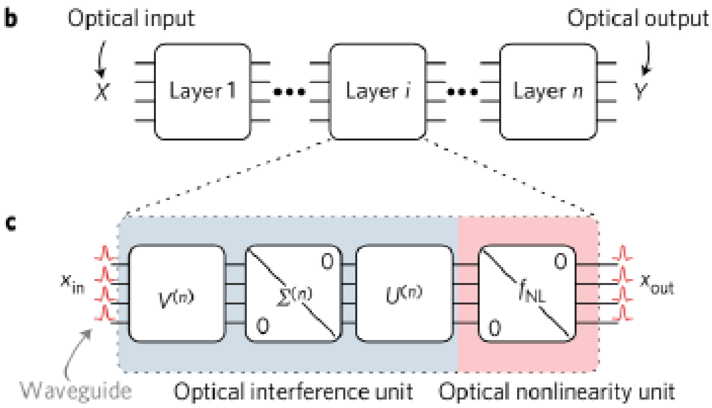

Fig.4 Functional diagram

The optical block of nonlinearity includes any real values of multiplication of a matrix by means of an optical separate beam, a phase and the switch.

The optical interference unit is implemented using optical nonlinearity, such as saturated absorption.

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